Updates on SuZIE and Python

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ABSTRACT: SuZIE and Python are two mature cosmic microwave background (CMB) anisotropy experiments. In this presentation we preview recent observations from both experiments.

KEYWORDS: **Cosmology; Cosmic Microwave Background: Observations**

1. PYTHON

Python has made observations from the South Pole in five different seasons. During the first three seasons (Dragovan et al. 1994, PyI; Ruhl et al. 1995, PyII; Platt et al. 1997, PyIII), observations were made at 90 GHz using a discrete, 4-beam chop with a roughly one degree beam.

During the fourth season (PyIV; See Kovac et al. 1998), a HEMT-based radiometer was used, allowing observations in two frequency bands from 37–45 GHz.

During its fifth observation season, a scanning secondary was installed to allow smooth triangle-wave scans, with a chopper throw of 17° in azimuth. This allows the synthesis of various "windows", which can be used to probe different angular scales. PyV densely samples roughly 600 square degrees of sky, providing information on the CMB anisotropies over scales from roughly $l = 30$ to $l = 300$.

Observations were taken in two regions of low 100 μm dust emission. The first is centered at $\alpha = 23.18$ hours, $\delta = -48.58°$ (J2000) and covers an area of roughly 7.5×56.5 square degrees. This field is centered on the same region observed in previous Python observing campaigns. The second region is centered at $\alpha = 3$ hours, $\delta = -62°$ (J2000) and covers an area of roughly 3×22 square degrees. This field overlaps with the region observed by the "South Pole" experiment (Gundersen et al. 1995). There were approximately 720 hours of data taken during the PyV campaign.

Figure 1 shows the Python III data plotted alongside the Python V data, modulated in such a way as to mimic the Python III four-point chop. The significant, consistent structure in both data sets is encouraging given the different frequencies of the two measurements, as it indicates that foregrounds are probably not the

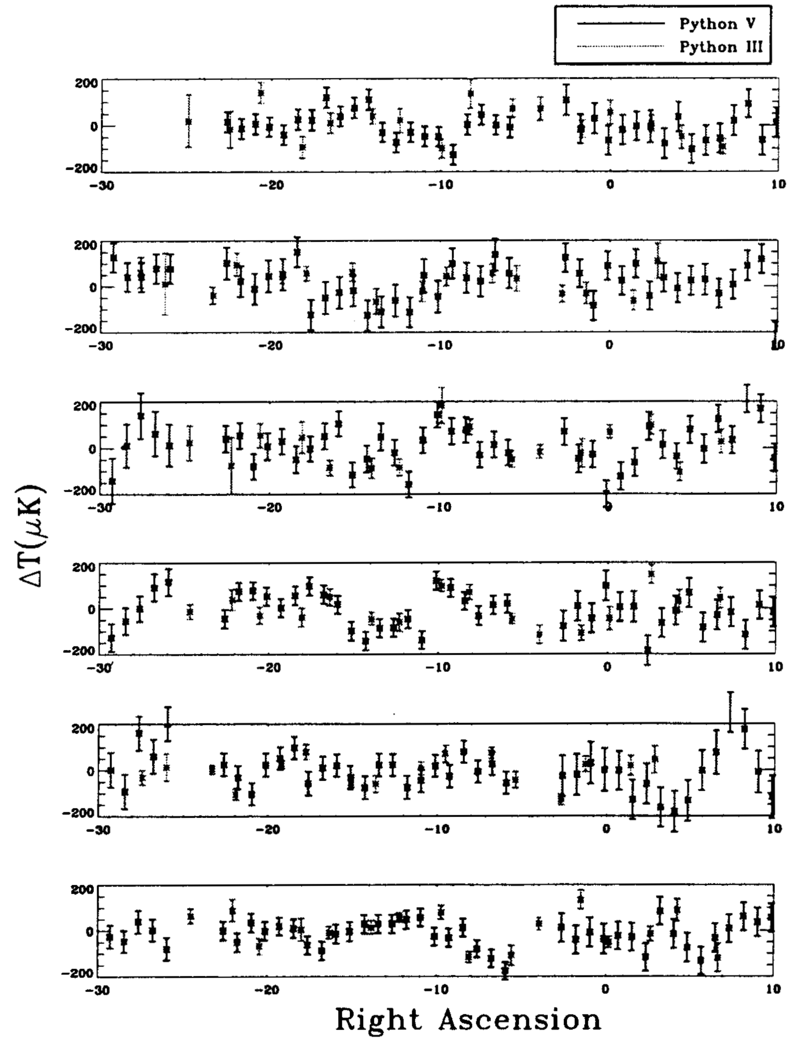

FIGURE 1. A comparison of the Python V data with the Python III data. The Python V data in the region of Python III were modulated using the chop pattern of Python III. Python V and Python III both detect CMB signal and are consistent with each other.

source of the fluctuations.

Figure 2 shows the power spectrum obtained by modulating the Python V data on a number of different scales. Each point is the result of a likelihood analysis on one modulation of the data treated independently. The rise in power from low multipole values to high is a signature of cold dark matter cosmologies.

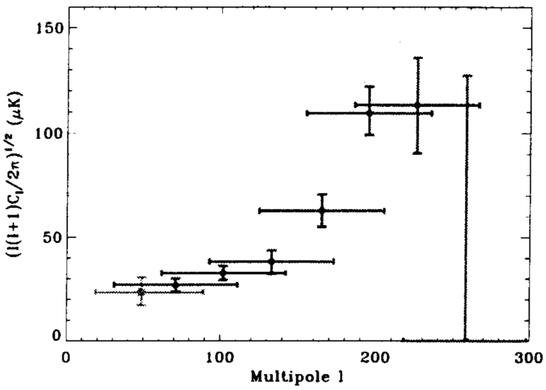

FIGURE 2. Python V band power spectrum, $\sqrt{l(l+1)C_l/2\pi}$ vs. multipole l for each of the modulations. The detections have 1σ error bars and the upper limits have 2σ error bars. The l range of each modulation is determined by the FWHM of its diagonal window function. See Coble et al. 1998 for more discussion of this plot.

The PyV data will be treated in more depth by Coble et al. (1998).

2. SUZIE

SuZIE was originally conceived to make millimeter-wave observations of both the thermal and kinetic SZ effects in clusters of galaxys from the Caltech Submillimeter Observatory. While it has done so (Holzapfel et al. 1997; Wilbanks et al. 1994), it can also provide valuable information about the primordial anisotropies at multipole values of roughly $l = 2000$. It employs a 2×2 array of pixels, each with three bolometers cooled to 300 mK. The pixel beamwidths are approximately 1.6 arcminutes, while the beam separations are approximately 5 arcminutes. Filters separate the input to each pixel into three frequency bands at 0.8, 1.4 and 2.1 mm. At each frequency, the two detectors in a row are differenced electronically. During this season, one row of two pixels did not work well. These data are ignored here.

Figure 3 shows the reduced data from the three fields observed by SuZIE at 1.4 and 2.1 mm.

The data from the third field (labeled "Ryle" in Figure 3) were taken to investigate the report of a detection of an SZ decrement towards the $z = 3.8$ quasar pair PC 1643+4631A,B (Jones et al. 1997). Figure 4 shows the likelihood of an SZ source as a function of amplitude and angular size given the SuZIE data. Note

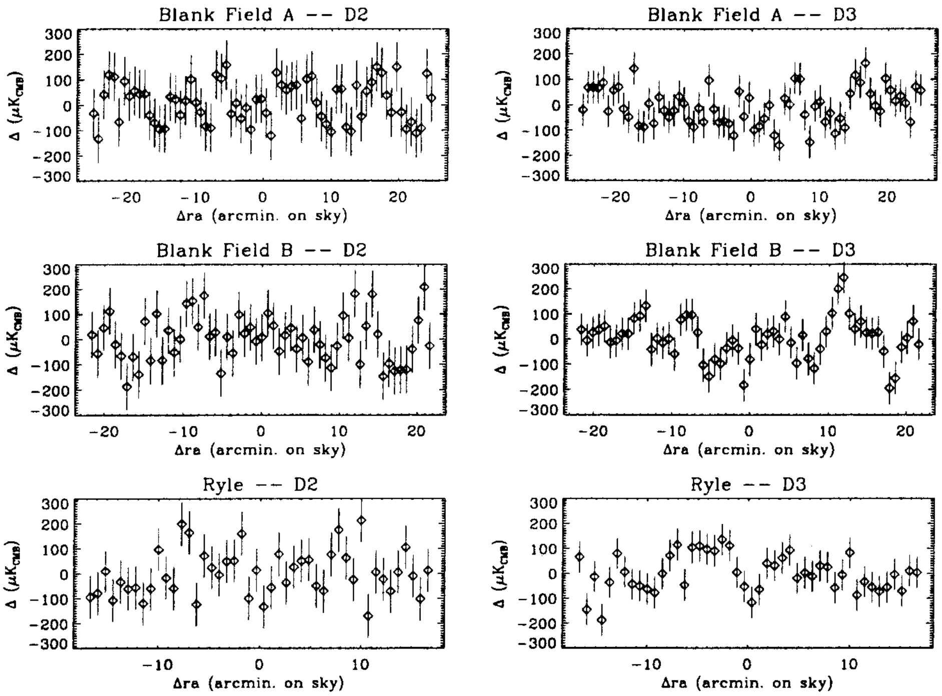

FIGURE 3. SuZIE Data. The three rows of plots correspond to the three different regions observed. The top two regions, Blank Fields A and B, were observed in order to search for primordial CMB fluctuations. The bottom field, which we call the "Ryle" field, was observed in an attempt to confirm the detection of a CMB decrement towards the z = 3.8 quasar pair PC 1643+4631A,B (Jones et al. 1997). The first column, labeled D2, is the 1.4 mm data, while the the second column, labeled D3, is the 2.1 mm data.

that a 60" source with $y = 10^{-4}$, as reported in Jones et al. 1997, is ruled out at greater than 5σ levels. It should be pointed out that these contours are dependent upon the source location and the model assumed.

Turning to primordial anisotropies, figure 5 shows likelihood functions for a variety of open models obtained from each of the SuZIE fields (see Ganga et al. 1997 for a description of the analysis method). All these likelihoods are roughly consistent with the COBE/DMR anisotropy detections.

These likelihoods show a number of features that are unique to data at these angular scales and frequencies. First of all, where there are detections, they are marginal at best. This simply indicates that for most CDM models, there is not much power at these angular scales. There is more in open models than in flat models, which is why we have focused on open models here. Interestingly, while there are detections for very low Ω models, there are not for models with $\Omega \approx 1$. This is not a contradiction, but simply an indication that the SuZIE data matches

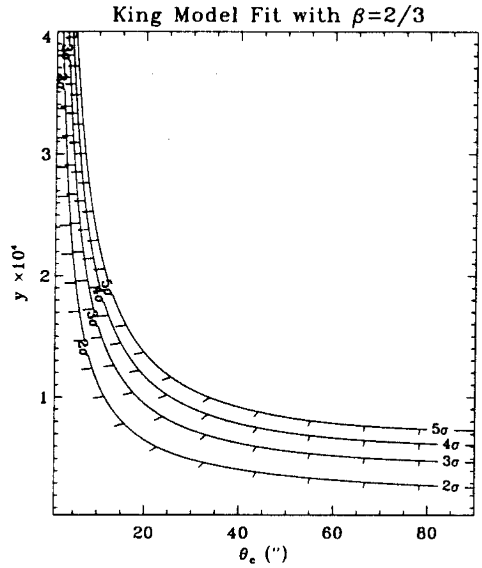

FIGURE 4. RYLE Fields Likelihood Contours as a function of source size and amplitude. Note that changes in the assumed source position and β to would change these contours.

some models better than others. We also note that some of the structure in these fields may be the imprint of flux from high-redshift, dusty galaxies (see, for example, Blain et al. 1998).

Finally, it should be noted that "Blank Field B" actually shows more structure than the "Ryle" field and "Blank Field A". This is further, though indirect, evidence against sources in the Ryle field, at *any* position.

The SuZIE data will be treated in more depth by Church et al. (1998).

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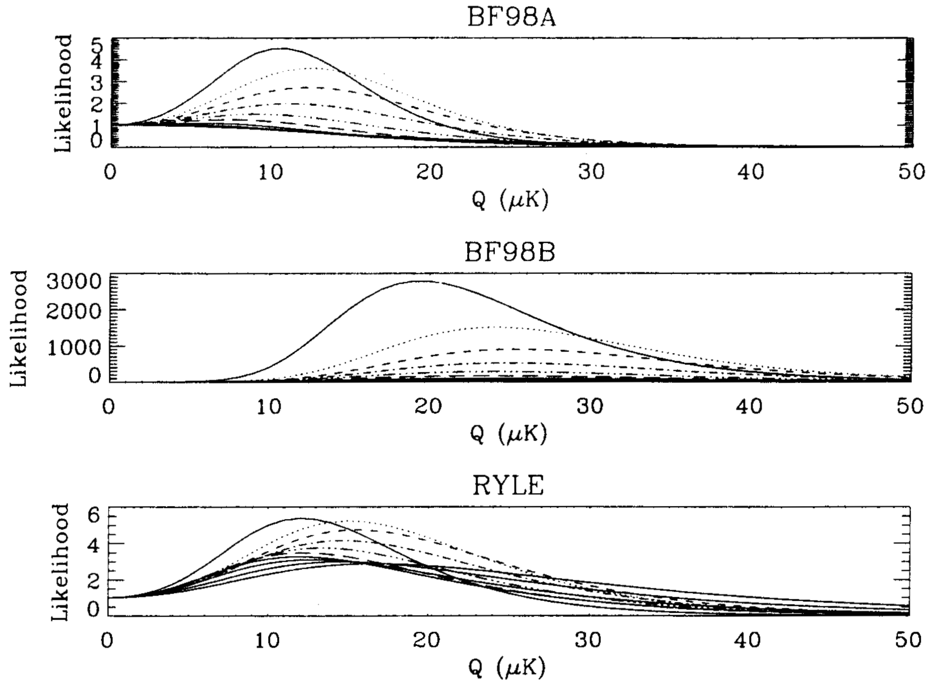

FIGURE 5. Likelihoods for the three SuZIE fields as a function of Q, the *implied* quadrupole moment of the anisotropies. Each of the models used assumes and age of the universe of $12 \cdot 10^{12}$ years and $\Omega_B h^2 = 0.13$. For each field, the likelihood with the largest maximum has $\Omega = 0.1$ (a solid line). The dotted lines correspond to $\Omega = 0.2$, the short-dashed lines correspond to $\Omega = 0.3$, the short-dashed and single dotted lines correspond to $\Omega = 0.4$, the short-dashed and triple dotted lines correspond to $\Omega = 0.5$, the long-dashed lines correspond to $\Omega = 0.6$ and $\Omega = 0.7, 0.8, 0.9$ and 1.0 are the solid lines with the smallest maximum likelihoods. Note that Q as used here is model dependent — we are not using Q_{flat}.

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